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AGRICULTURAL POLLUTION CONTROL: IMPLICATIONS FROM THE RURAL CLEAN WATER PROGRAM[1]

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ABSTRACT: The Rural Clean Water Program has provided a unique opportunity to study the economics of agricultural nonpoint source pollution control. Several implications for improving the economic efficiency of future agricultural nonpoint source pollution control programs can be drawn from the results. First, individual projects should be targeted towards water bodies that have water quality problems causing economic damages. Considerable variation can exist among areas in the magnitude of economic damages, which may not be proportional to physical impacts. Second, the relative costs and effectiveness of the practices selected to reduce the delivery of pollutants can vary dramatically from one location to another. Early identification and emphasis on cost-effective BMPs can substantially reduce project costs and may make a project economically justifiable that would not otherwise be so. Finally, some projects that do not have potential economic benefits from water quality improvements exceeding government cost may have on-farm benefits from reduced costs and increased long-term yields that are sufficient to make total benefits (water quality and on-farm) exceed costs.
(KEY TERMS: economics; cost/benefit; cost-effectiveness; nonpoint source pollution; water quality.)

INTRODUCTION

Control of point sources of water pollution in the 1970's and early 1980's was not sufficient to meet national water quality goals. Additional measures have been necessary to control nonpoint sources of pollution. Agriculture is generally recognized as the primary contributor of nonpoint source pollutants (Nonpoint Source Task Force, 1985).

This paper discusses implications for the design of a national agricultural nonpoint source pollution control program, based on an ongoing economic evaluation of the experimental Rural Clean Water Program (RCWP). Specific results of the economic evaluation are presented to illustrate the points that we wish to make. Details concerning data, models, and estimation procedures are discussed by Bouwes and Young (1984); Carvey (1984); Crowder and Young (1984); Erickson (1984); and Gum, *et al.* (1984). The economic evaluation of RCWP demonstrates that by targeting specific locations nonpoint source pollution can be controlled and that the benefits of control can exceed the costs if impairments to water use affect a sizable number of people and costs can be minimized through applying the most cost-effective practices.

RURAL CLEAN WATER PROGRAM

The experimental Rural Clean Water Program (RCWP) was initiated in 1980 to demonstrate the effectiveness of an agricultural nonpoint source program. Approximately $60 million was allocated to 21 projects. These projects were selected to represent the range of potential agricultural nonpoint source problems. Farmers choosing to participate in the program were eligible to receive cost share funds for implementing practices to reduce pollution runoff from their land. Cost shares for these "best management practices" (BMPs) could range up to 75 percent of eligible costs with a maximum of $50,000 per farm.

Five of the RCWP projects received additional allocations to permit comprehensive monitoring and evaluation. These projects were: the Idaho Rock Creek Project, the Illinois Highland Silver Lake Project, the Vermont St. Albans Bay Project, the Pennsylvania Conestoga Headquarters Project, and the South Dakota Oakwood Lakes-Poinsett Project. The comprehensive monitoring and evaluation studies include both water quality and economic components. The water quality problems and use impairments originally identified for the comprehensive monitoring and evaluation projects are listed in Table 1, along with projected improvements in water quality.

ESTIMATED OFFSITE BENEFITS

Estimates of the economic value of the water quality improvements for the five RCWP projects are presented in Table 2. Total estimated benefits of BMP implementation range from $0.1 million for the Conestoga Headwaters in Pennsylvania project to $4.9 million for the St. Albans Bay Vermont project. The much higher benefit estimate for St.

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TABLE 1. Water Quality Problems, Impairments, and Expected Improvements.

Project	Source of Pollution	Principle Best Manaement Practices	Water Quality Problem	Use Impairment	Water Quality Improvements
Idaho (Rock Creek)	Sheet and rill erosion erosion from irrigated cropland	Irrigation management, conservation tillage, sediment	Turbidity, sediment	Fishing, water storage, power generation, ditch capacity	Major reduction in sediment in Rock Creek; minor improvements in Snake River
Illinois (Highland Silver Lake)	Highly erodible natric soils	Conservation tillage, sediment retention systems, terraces	Turbidity, sediment	Water storage, water treatment, fishing	Some reduction in turbidity; minor change in lake sedimentation
Pennsylvania (Conestoga Headwaters)	Excess fertilization with animal manure, commercial fertilizer, concentrated animal production	Animal waste storage, terraces, nutrient management	Sediment, phosphorus in surface water, nitrates in surface and ground water	Water supply, fishing, Chesapeake Bay	Limitied improvement due to large land area and limited farmer participation
South Dakota (Oakwood-Poinsett)	Excess use of fertilizers and pesticides	Nutrient management, pesticide management, conservation tillage	Nitrates in surface and ground water, phosphorus in surface water	Water supply, swimming, boating, fishing, property values	Some improvement in surface and ground water
Vermont (St. Albans Bay)	Animal wastes, sewage treatment plants	Animal waste storage	Phosphorus (algae, aquatic weeds)	Swimming, boating, fishing, property values	Major reductions in algae and aquatic weeds

TABLE 2. Estimated 50-Year Benefits Compared With Costs for Five RCWP Projects.

Item	Idaho Project	Illinois Project	Pennsylvania Project[a]	South Dakota Project[a]	Vermont Project
			BENEFITS		
Offsite (water quality):					
Recreation	0.4	+[c]	+	>1.4	3.9
Water Storage	0.0	0.0	NA[d]	NA	NA
Property Values	NA	NA	NA	+	1.0
Water Conveyance	0.2	0.0	NA	NA	NA
Water Treatment	NA	0.2	+	+	NA
Other	0.2	NA	NA	NA	+
Total Offsite	**0.8**	**0.2**	**0.0**	**>1.4**	**4.9**
Onsite Benefits:					
Soil Productivity	0.8	0.0	0.1	+	NA
Reduced Farm Costs	NA	NA	NA	NA	0.2
Total Benefits	**1.6**	**0.2**	**0.1**	**>1.4**	**6.9**
			COSTS		
Government[e]	3.4	1.6	1.0	1.4	3.9[f]
Private	3.3	0.3	0.3	0.0	NA
Total Costs	**6.7**	**1.9**	**1.3**	**1.4**	**3.9**
Benefit/Cost Ratios	**0.2**	**0.1**	**0.1**	**>1.0**	**1.8**

[a]The economic evaluations of the Pennsylvania and South Dakota projects were started a year later and were funded at significantly lower levels than the economic evaluations of the other projects.

[b]Adjusted to a 1980 base and discounted to current value at 7.875 percent rate.

[c]Positive benefits accrue but total value is less than $50,000.

[d]Not applicable.

[e]Includes cost share payments, technical assistance, and information and education costs.

[f]Includes costs of phosphorus waste water treatment for the City of St. Albans.

Albans Bay stems from two major factors – a greater marginal improvement in water quality and a greater number of people affected by the improvement. The importance of these factors can be seen better by examining how total benefits were estimated.

In Idaho, sediment in irrigation return flows and in Rock Creek will be greatly reduced. This will generate $0.4 million in benefits to recreational fishing and will reduce ditch cleaning costs by an estimated $0.2 million. However, this improvement in Rock Creek will minimally affect the quality of water downstream in the Snake River. Because of the hydrologic features of the Snake River, sediment from streambanks and the river bottom would be picked up, largely offsetting any savings from reductions in sediment entering from Rock Creek. Thus, water storage or power generation benefits appear negligible. The total estimated water quality benefits over 50 years are $0.6 million. Additionally, the crop residue cover from use of conservation tillage is projected to improve upland game habitat, with a hunting benefit estimated at just over $0.2 million. The total offsite benefits of RCWP in Idaho would be $0.8 million.

In the Illinois Project, sediment entering the lake will be reduced, in turn, reducing the turbidity in the lake. The costs of water treatment to remove sediment will be lowered by some $0.2 million. Also, recreational fishing will marginally improve but, because of limitations on access and on boat size, only some $24,000 in benefits will be generated. Water storage benefits appear negligible because much of the sediment will remain in suspension and pass over the dam and because the lake's capacity is large relative to future demand. Thus, the total offsite benefits of $0.2 million appear likely over a 50-year period.

For the project in Pennsylvania, the limited nature of BMP implementation over a wide area will result in minimal improvement in water quality. Localized improvements in ground water will result in small benefits to households from improvement in water wells. In addition, minor improvements in surface water quality are expected to occur. Since the potential for increased recreational use of the Conestoga River is limited, recreational benefits are expected to be positive but quite small.

In South Dakota the offsite benefits are projected to be substantial. The drainage basin includes several popular recreational lakes that have been degraded by agricultural nonpoint source pollution. If recreational use of the lake increased by 4 percent due to water quality improvement, the recreational benefits would exceed $1.4 million. There is a significant number of seasonal homes located adjacent to the lakes, and the value of these properties is expected to increase in conjunction with the improvement in water quality. The magnitude of this increase has not been estimated. The ground-water aquifer in the South Dakota project area serves as a source of potable water for local residents. Positive benefits are expected to occur with water quality improvement.

In the Vermont Project, greatly reduced phosphorus loadings from RCWP and better sewage treatment will improve the water quality in St. Albans Bay over time, to near that in the larger Lake Champlain. This will produce swimming and other recreational benefits of nearly $4 million and will also increase recreational property values by over $1 million. The costs of weed treatment removal will be reduced by $27,000. Thus, the total offsite benefits over 50 years are estimated to be nearly $5 million.

ONSITE BENEFITS

In four of five projects, RCWP is generating some onsite economic benefits from preserving soil productivity or from reducing farmers' operational costs, which more than offset their RCWP installation costs. In Idaho, the planned implementation of conservation tillage and other practices that help keep soil in place on the fields will reduce long-term soil productivity loss and generate benefits estimated at $0.8 million (Table 2). In this case, these productivity benefits are as great as the offsite benefits. In Pennsylvania, heavy manure applications are largely offsetting soil erosion. In the Illinois project, because soils are deep and fertile, long-term productivity benefits are negligible. In the Vermont project, the installation of improved animal waste storage facilities reduces manure handling and fertilizer costs over time by more than the farmers' initial share of putting in the systems. This negative cost of over $2 million can be considered an onsite private benefit. Note that it is about 40 percent as large as the public benefits.

COSTS

Each project has two cost components: government costs and private costs (Table 2). The government costs range from $1.0 million for the Pennsylvania project to $3.4 million for the Idaho Project. This cost includes government cost-share payments, technical assistance, information and education expenditures, and local administrative costs.

Private costs are the net costs before taxes that the farmer incurs from paying his share of the BMP installation, plus the net change in operating costs. Notice that the private costs in the Idaho project are very high, nearly equal to government costs. It appears that the farmers in the Idaho project are able to shift much of this cost back on the government through tax credit and depreciation. By comparison, in the Vermont Project the net private costs are zero because the reduction in operating costs exceeds the installation cost, so the negative cost gets listed as a private benefit.

BENEFITS VERSUS COSTS

How do the estimated benefits in the comprehensive monitoring and evaluation projects compare with the costs of implementing the projects to generate the benefits? The answer to this question is affected by which benefits we compare with which costs. First, let's compare total benefits, including both public and private, with total costs, again including both government (or public) and private. The Vermont project with a benefit/cost ratio of 1.8 to one and the South Dakota project with a benefit/cost ratio that exceeds 1.0 are the only projects of the five that are economically justified (Table 2). For these projects the total economic benefits will likely exceed the costs. In the Idaho, Illinois, and Pennsylvania Projects, the total economic benefits are projected to be only one-fourth or less as large as the total costs.

If we say that these projects were undertaken to improve water quality and produce offsite benefits and we are interested in how much we are getting for the government buck, we would compare offsite benefits against government costs. When this is done, the benefit to cost ratio for the Idaho Project drops to 0.2 and the ratio for Pennsylvania approaches zero, while the others remain the same.

IMPLICATIONS

The results from the individual economic evaluations of the five comprehensive monitoring and evaluation RCWP projects can be generalized to provide guidance in planning future projects and programs designed to control agricultural nonpoint source pollution. For convenience we group the implications from the economic evaluations into four categories: economic impairment, costs and effectiveness of BMPs, incentives to participate, and benefits versus costs.

Before drawing some implications from these evaluations, several limitations need to be pointed out. First, these evaluations are interim; RCWP will continue through 1991. Second, the RCWP projects were not selected on the basis of anticipated benefit/cost ratios, but rather to experiment and try out the program in different problem and geographical settings. Although the Idaho, Illinois, Pennsylvania, and some other RCWP projects may have low benefit/cost ratios, the information they provide will be valuable for guiding future programs. A third limitation is that the RCWP projects are not representative statistically of possible agricultural NPS projects. Thus, the results should not be used to generalize about the economic efficiency of a future program.

Economic Impairment

The importance of pre-project assessment of the economic impairment and of the potential benefits from improving water quality is demonstrated by the economic evaluation of RCWP. The potential benefits can vary considerably among areas and should not be measured only by examining levels of pollution. Each of the RCWP projects were targeted to areas with highly polluted water. However, the estimated offsite water quality benefits for pollution control ranged from under $250,000 for the Illinois Project to nearly $5 million for the Vermont Project (Table 2). Note that the estimate of negligible water quality benefits for the Pennsylvania Project reflects the failure to implement a sufficient number of the appropriate BMPs. If water quality were improved in the project area, the magnitude of the offsite benefits would be significant.

A key factor affecting potential offsite benefits appears to be the level of demand for the water resource, particularly with regard to recreational opportunities. Potential benefits depend on the number of activities affected and the economic importance of these activities. In Vermont and South Dakota, the likely recreational benefits are sizable, while in the other three projects they are relatively small. In addition to increased recreational opportunities, other offsite impacts associated with the various RCWP projects include property values, sedimentation of water storage facilities, power generation costs, water supply and treatment costs, and ditch cleaning costs.

The importance of measuring the contribution of agricultural nonpoint source pollution to water quality and determining an economic impairment before project implementation is illustrated in the case of the Illinois RCWP project. When the project was initiated, the loss of storage capacity from deposition of sediment in the Highland Silver Lake was identified as the principal impairment. Reductions in erosion in the watershed would reduce sediment delivery to Highland Silver Lake, which is the primary source of drinking water for the City of Highland. Substantial offsite benefits were envisioned through the elimination of the need for dredging the lake or finding an alternative source of water. However, subsequent analysis of the lake's siltation revealed that much of the sediment was not settling out and remaining on the lake bottom but rather was either staying in suspension or being resuspended and passing through the lake. Also, the reservoir capacity was large relative to the future demand. Thus, there was no significant problem in terms of lost water storage capacity in the lake, and the primary benefit identified for the project had negligible economic value.

A similar situation occurred in the Rock Creek Project in Idaho. Reduced siltation of power-generation reservoirs behind dams on the Snake River was identified as a significant potential benefit from the Rock Creek Project. However, subsequent evaluation revealed that reductions in erosion in the Rock Creek watershed were unlikely to significantly affect the water storage facilities 100 miles downstream. Although measurable reductions in sediment delivery to the Snake River occur, the Snake River itself will tend to pick up replacement sediment from streambanks and the river bottom.

In addition to offsite water quality benefits the Idaho and Pennsylvania Projects generate onsite soil productivity benefits. A policy question is whether offsite and productivity benefits should receive the same or differing priorities in allocating resources. A similar concern exists with regards to wind erosion. Although none of the RCWP projects experienced wind erosion, in some regions offsite wind erosion damages can be significant. Whether or not productivity and wind erosion benefits are included with water quality benefits could make a major difference in the economic feasibility of a project.

Costs and Effectiveness of BMPs

The costs and effectiveness of BMPs (best management practices) to improve water quality are dependent upon the proximity to watercourse, surface slope, soil type, timing of precipitation, other BMPs in place, agronomic practices in the area, and the water quality problem being addressed. In general BMPs were effective in improving water quality in the projects. However, the relative effectiveness varied considerably from one project to another. For example, in Vermont animal waste storage reduced the quantity of nutrients reaching the watercourse by permitting more timely application to meet crop needs and avoid runoff. A different result occurred in Pennsylvania where Lancaster County, the site of the RCWP project, has the highest concentration of animals per acre of any county in the United States. Installation of animal waste storage facilities conserves nutrients, resulting in greater amounts of high nutrient manure being applied at a given time that would otherwise occur. However, the increased levels of nutrients resulting from animal waste storages surpasses the amount of nutrients that the crops can use. These excess nutrients appear to be moving downward into the ground water and subsequently to the Conestoga River in baseflow (Crowder and Young, 1984). Thus, delivery of nutrients to the watercourse actually increases or remains constant with the installation of the BMP.

A BMP preferable to long-term storage in the Pennsylvania Project might be short-term manure storage and an application mode that increases nitrogen volatilization. Other alternatives that could increase the effectiveness of the project include the removal of the manure from the farm to other areas that can use the nutrients and the institution of disincentives for farmers in the project area to have such high concentrations of animals on their farm.

The relative cost effectiveness of individual BMPs is also dependent upon the type and location of the water resource to be protected. Soil conservation practices, such as terraces and conservation tillage, are generally effective at reducing surface losses of pollutants. If the concern is protection of a ground-water resource, the effectiveness of these practices is greatly reduced. The advantage of soil conservation practices is that they reduce the velocity of the water as it flows off the land, thereby reducing the amount of soil and attached nutrients that can be carried with the water. Also, since the rate of flow is reduced, more water and nutrients infiltrate into the ground. Thus, in attempting to protect a ground-water resource as in the Pennsylvania and South Dakota projects, soil conservation practices may actually increase the discharge of nutrients and pesticides to the ground water. Modeling results from the Pennsylvania project show that some BMPs, such as fertilizer management, can reduce loadings to both surface and ground water (Crowder and Young, 1984). Heavy reliance on runoff-reducing practices such as terraces and conservation tillage can have negative effects on ground-water quality, thereby solving surface water problems by impairing ground water.

The selection and placement of BMPs also impacts the relative costs and effectiveness of a water quality program. With water quality, the concern is reducing pollutants delivered to the waterbody. A given reduction in delivery of pollutants can be attained by intensively treating a small area that has a high discharge or extensively treating a large area. For example, in the Idaho RCWP project, initial emphasis was given to fairly costly structural BMPs that trapped sediment at the end of the field or improved irrigation. Alternative BMPs were examined to determine more cost-effective ways of reducing sediment delivery. One such BMP was conservation tillage (including no-till), which if it could be implemented throughout the watershed, would not only reduce sediment delivery below that projected for the original set of BMPs, but it would also reduce costs. In addition, conservation tillage would help retain soil in place on the field, rather than trapping it at the bottom, and thus producing a soil productivity benefit.

Incentives to Participate

A voluntary water quality program such as RCWP cannot succeed without providing the appropriate participation incentives to farmers contributing to the problem. RCWP provides cost sharing up to 75 percent of the cost of installing BMPs with a maximum of $50,000 per farm. In addition, RCWP funds educational programs to promote and demonstrate the advantages of BMPs to farmers. The economic evaluation of RCWP indicated several opportunities for farmers to gain from participation in the program.

The primary BMP in the St. Albans Bay project in Vermont is animal waste storage. In the case of animal waste storage structures, nutrients that can be utilized for crop production are conserved, resulting in reductions in purchased fertilizer. The economic evaluation of the animal waste storage BMP for the St. Albans Bay area revealed that a farmer could recapture most of the costs of installing an animal waste storage structure over a 20-year planning horizon due to the savings in fertilizer purchases. Thus, farmers may be willing to adopt manure storage structures at a lower costs share rate than the present 75 percent that is available in the project. This would result in substantial savings to the government with minimal reduction in the overall level of implementation of the animal waste storage BMP.

An opposite phenomena occurred with manure storage and handling in the Pennsylvania project. In this instance the nutrients saved by manure storage have a low value to the farmer because he has sufficient nutrients to meet crop needs even when he uses the relatively inefficient (in terms of nutrient savings) daily spreading system. Thus, if society wants these farmers to switch to less polluting manure management systems, cost sharing or regulations will be necessary to induce participation.

As previously mentioned for the Idaho project, conservation tillage was found to be a cost-effective BMP for preventing erosion. Conservation tillage provides two benefits to the farmer that will encourage participation in the project. First, net income is projected to be higher with conservation tillage than for conventional tillage practices. Second, adoption of conservation tillage provides long-run productivity benefits. While a farmer may not place a high present value on these benefits, they are worth something to him.

An additional incentive that must be kept in mind with structural BMPs, such as terraces or animal waste storage structures, is the income tax deductions that are available for this type of investment. Much of the farmer's costs for structural BMPs can be deducted from income taxes, which provides an additional incentive to install the BMPs.

The payback period for nutrient savings from manure storage, soil productivity, and income tax writeoffs may be too long for a farmer's planning horizon. Low-interest loans may be a sufficient incentive for farmers to adopt practices that have long-term paybacks.

Farmers can also benefit from localized improvements in water quality. In Pennsylvania installation of BMPs created localized improvements in ground water. Frequently, the ground-water resources that were improved were the source of drinking water for the farm. Farmers are more likely to participate if the benefits accrue directly to them such as reduced health risks associated with drinking contaminated water.

Benefits Versus Costs

Comparison of the benefits and costs of the five RCWP projects indicates that only two of the projects have or will likely have benefit-cost ratios that exceed one. Nevertheless, several implications can be derived from the comparison.

Is the measure of the success of a RCWP project only offsite water quality improvements or should onsite long-run productivity benefits be included? The mix of projects to be funded will be radically different if either offsite or productivity benefits are considered in isolation. If the Idaho project had been originally designed to emphasize conservation tillage rather than the mix of structural practices selected, the benefit-cost ratio could have exceeded one, even though sediment delivery and offsite benefits would be similar. The long-run productivity benefits and cost savings associated with conservation tillage make the difference.

The benefit-cost ratio is influenced by the size of the project. For example, as the Conestoga Headwaters project in Pennsylvania has been implemented, the B/C ratio is close to zero. Even if the project were implemented as planned, the ratio would remain low. However, if the project area were expanded and a high level of participation were achieved, substantial offsite benefits could be generated. A larger project would protect the water supply for the City of Lancaster and would influence water quality in Chesapeake Bay, thus potentially generating large benefits.

CONCLUSIONS

The RCWP has provided a unique opportunity to study the economics of agricultural nonpoint source pollution control. Evaluation of the program highlighted four factors that will improve the economic efficiency of future agricultural nonpoint source pollution programs.

Individual projects should be targeted towards water bodies that have water quality problems that are causing economic damages. Existence of a polluted water body is an inefficient reason for targeting an area for water quality improvement via agricultural nonpoint source pollution control. The elimination or reduction of the water quality impairment must have a measurable economic value.

The relative costs and effectiveness of the practices selected to reduce the delivery of pollutants can impact program costs substantially. In certain instances, intensive treatment of critical sources of pollution is cost effective, while in other areas extensive treatment of a watershed with low cost BMPs is preferable. In addition, the relative effectiveness and cost effectiveness of individual BMPs can vary dramatically from one location to the next. The relative cost effectiveness of individual BMPs is also dependent upon the type and location of the water resource to be protected. A BMP, such as a terrace, may be quite effective in reducing surface losses of pollutants, but may be ineffective in protection ground-water resources.

The control of agricultural nonpoint source pollution cannot be accomplished without adequate participation by farmers who are contributing to the water quality problem. Cost sharing and the use of low cost or no cost BMPs are two methods that were successful for RCWP. Private benefits can accrue to farmers through the use of BMPs. Erosion reduction can maintin the productivity of soil over time and can reduce annual losses of nutrients from fields. Nutrient management and manure storage also reduce fertilizer costs.

Finally, even if a project is successful in encouraging farmers to participate using cost effective BMPs to improve water quality at a site that has economic value, the project may not meet a benefit cost criteria. Only two of the five RCWP projects evaluated had benefit cost ratios that exceeded one.

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